HEIMDALL: a tool for effective disaster preparedness and response

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Disaster management operations: status-quo

In recent years, the frequency and amplitude of natural and human-made disasters increased in Europe and worldwide in light of the extreme climate changes, hence determining highly complex and challenging disaster management operations. In particular, prolonged droughts and overall increased temperatures, forest fires becoming increasingly intense in fire-prone regions, and extreme rainfall events leading to flood and flash flood events are being observed with increasing frequency every year. In light of this unprecedented ecosystem deterioration, an effective disaster management approach calls for strategic agency cooperation on risk assessment and management between all relevant actors, i.e. firefighters, medical services, police, civil protection, forest services and volunteer associations. Last but not least, as cross-border emergency situations may occur more often, emergency management practices need to enhance organisational and technical interoperability between agencies from both sides.

As such, efficient information exchange among actors is fundamental. Tools for improving information sharing, such as the common operational picture (COP), are needed to ensure cooperation and a coordinated response. Beyond the response itself, common capabilities can be improved by joint training, preparedness and information exchanges of known threads, plans and procedures.

The challenge to achieve effective interoperability among agencies from different countries/regions is that they have different processes, regulations, formats, or languages. Hence, the main difficulty is to produce a common format or structure to enable the provision of harmonised information on disasters. Furthermore, most organisations still use a paper-based system to keep track of the information, making the management and sharing of information very hard.

A digital scenario model would allow organisations to store, share and manage all that information, establish common operational objectives with others involved in an emergency and reinforce the cooperation efforts towards more efficient and effective response actions. New and sophisticated technologies can support the involved actors and decision makers by providing them with detailed information about the situation at hand. For instance, in-situ sensors can monitor the situation and certain parameters; information provided by first respondents in the field using portable devices (e.g. locations, images and videos) can show a clear picture to decision makers in the command and control rooms or in an incident command post; Earth Observation services can deliver detailed imagery when wildfire hazard potential is high; simulation tools can predict the evolution and behaviour of hazards;

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and innovative tools for assessment estimates on people, structures and the environment, bring previously inaccessible insights into ongoing risk scenarios. These are tools that are already available and enable decisions making on a broader and clearer basis. Simultaneously, to support decision makers in the most efficient way, it is necessary to focus and fuse all this information in a clear manner.

How can HEIMDALL help?

In view of the aforementioned challenges, the goal of the HEIMDALL project has been to build up a tool that facilitates knowledge and data exchange processes to cope with complex crisis situations that require participation, coordination, and cooperation of multiple first-responder organisations and international aid. The resulting HEIMDALL system, which has been conceived and developed in the course of the project, is a flexible and modular platform for multi-hazard emergency planning and management that combines data exchange, scenario building and situation assessment functionalities for training, preparedness and response phases of an emergency. The flexibility allows the system to be enhanced with new services, sensors and inputs and adapt it for basically any hazardous situation. In particular, the project focus has been on three main hazards, namely landslides, wildfires and floods. Last but not least, end-users can exploit the services provided by HEIMDALL for the decision making process.

The life-cycle model of decision making during disaster management operations is therefore implemented by the HEIMDALL through nine consecutive steps:

1. Different data sources **detect** an incident and **gather information**—drones for hotspot detection and monitoring, Earth observation data and related maps, in situ landslide sensors for real-time monitoring of landmass movements.
2. Scenario **matching** provides similar situations from the database of scenarios. The user can tune matching parameters to find suitable solutions. Lessons learnt and response plans can be considered and applied either from past, hypothetical events or scenarios made available from other organisations fostering knowledge exchange.
3. Simulation provides a **forecast** of the situation development. One simulator for each hazard (fire, flood, landslide) is available, which provides hazard extensions, weather-based data, etc.
4. Situation and impact assessment tools help the user analyse **potential consequences** to develop the best-suited working strategy. Based on simulation and Earth observation data, the impact on buildings, roads and humans are determined.
5. User considers **policies, regulations and procedures**, checked with the HEIMDALL database.
6. HEIMDALL decision **support** tools provide information on options and contingencies derived from simulation, Earth Observation and impact assessment results. For instance, shelters, safe and unsafe spots are determined and presented to the user.
7. HEIMDALL **communication** system sends relevant information to users in the field and information to the public based on standard protocols. The HEIMDALL app receives alert messages, situation reports, waypoints with command messages and chat messages. The app can be used to send information from the field, e.g. locations, images and answers to waypoints.
8. Scenarios, response plans and decisions are **shared** between organisations at a national and international level. Organisations can form groups to respond jointly; the system automatically updates all available information among members of the group. Besides this, organisations can publish and subscribe to scenario information setting detailed access rights to satisfy the sensitivity of data.
9. HEIMDALL **stores** response plans, decisions taken and lessons learnt in a formatted way allows organisations to find a common structure and foster knowledge exchange.

Figure 1: Preparation of a drone for hotspot detection and monitoring.

All these services and products are provided through a web-based graphical user interface accessible from anywhere with a proper internet connection.

A cooperative design for effective collaboration

The HEIMDALL system results from cooperative, interactive, and iterative efforts between end-users and technical institutions, who joined forces to design and implement effective and accepted system capabilities successfully. Therefore, it is tailored to specific user requirements translated into functionalities that observe specific ethical, legal and social issues.

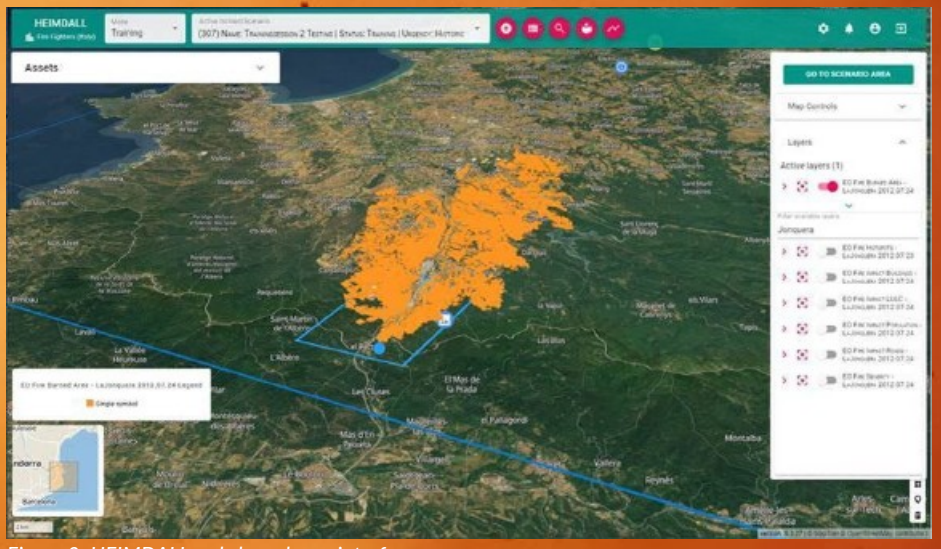

Figure 2: HEIMDALL web-based user interface.

Release planning for incremental system development has included a series of end-user workshops to test and evaluate the preliminary system releases and gather end-user feedback until the final demonstration. This last event took place in January as a hybrid event (remote and live participation) and was conducted as a drill based on multi-hazard emergency scenarios that included the historical fire event in La Jonquera (July 2012) and a fictional flood event at the Ter river, both occurring in the region of Girona (northeast Spain). The execution of the exercise counted on the participation of local emergency services (firefighters, police, civil protection, medical services, forest services and forest volunteers)

Figure 3: End-user workshop.

playing their actual role in an emergency. End-users operated the system as if it were a real case. The EC and event participants have provided important acknowledgement and recognition, echoed by the feedback from many stakeholders who have highlighted the potential of the system in operational activities aimed at managing real emergencies.

"HEIMDALL allows us to have channels for information sharing available from the very early stage of the emergency. It's really important, for example, to monitor the evolution of the fire to anticipate the impacts on the vulnerable elements or critical infrastructures within the next few hours."

Civil protection

"The use of such a platform is fundamental to facilitate the coordination of the different agencies, and, in terms of mobility, to help with the identification of roads that need to be blocked and the alternative routes available."

Police

"We understand HEIMDALL as a common platform where all the organisations involved, i.e. commanders, in-field practitioners, volunteers and local entities, can share the information because this is nowadays one of the main shortcomings in cross-organisational emergency management."

Forest Volunteer

"HEIMDALL allows us to look at the future, innovating in new tools and solutions that provide a response to the most important challenges, and helping to focus on the highest priority needs to address them."

Firefighter

Project partners

German Aerospace Center (DLR)

Pau Costa Foundation

Space Hellas S.A.

Tecnosylva S.L

Avanti Communications LTD

Eberhard Karls Universität Tübingen

Université de Strasbourg

Centre Tecnològic de Telecomunicacions de Catalunya

CIMA Research Foundation

Institut Cartografic i Geologic de Catalunya

Department d'Interior, Generalidat the Catalunya

Scottish Fire and Rescue Service

Frederiksborg Fire and Rescue Service

Croce Rossa Italiana

PROJECT SUMMARY

The HEIMDALL project aims to improve societies' preparedness to cope with complex crisis situations by providing a flexible platform for multi-hazard emergency planning and management for actors involved in disaster management. The result is a cooperative management tool that provides data exchange, scenario building and situation assessment functionalities for training, preparedness and response planning.

PROJECT LEAD

Dr Tomaso de Cola holds laurea degree in telecommunication engineering and a PhD in Electronic and Computer Engineering, Robotics and Telecommunications from the University of Genoa, Italy. He worked with the Italian Consortium of Telecommunications (CNIT) as a scientist researcher between 2002–07. He has been with the German Aerospace Center (DLR) since 2008, where he is involved in different projects focusing on satellite communications and emergency networks. He has also served on the technical program committee at several IEEE International Conferences, as a guest and associate editor for several IEEE magazines and journals, and as chair of the Satellite and Space Communications technical committee within IEEE ComSoc.

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